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SMALL SCALE MAGNETIC FIELD MAPPING WITH HIGH TEMPORAL RESOLUTION

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ABSTRACT. Two dimensional maps of the longitudinal magnetic field can be readily calculated for small-scale magnetic regions. Here we use an one-hour time sequence of high spatial resolution (0.75 arc sec) filtergrams, obtained at the Sacramento Peak Vacuum Tower Telescope with the universal filter (UBF) in the wings of the magnetically sensitive λ 6103 CaI line. The time difference between two magnetic maps is 32 sec. The measurements of the magnetic field in the blue wing are about 40% higher than in the red wing.

1.-INTRODUCTION

Small-scale magnetic fields far from active regions have been the subject of many publications in the last two decades (Frazier and Stenflo, 1972; Howard and Stenflo 1972; Koutchmy and Stellmacher 1978; Stenflo and Harvey, 1985; Title *et al*, 1987; Grossmann-Doerth *et al*, 1989). Efforts have been made for high spatial resolution observations, but the question of whether small-scale magnetic fields are unresolved and thus quite strong, even when they appear weak, is still open. If the spatial resolution is poor, it is not easy to evaluate the contribution of each of the fine structures seen in a high resolution observation; still, even in high resolution observations there may be unresolved "flux tubes" as Stenflo (1973) has inferred.

In a previous publication we presented maps of small-scale magnetic fields obtained from high resolution spectra (Dara and Koutchmy, 1983); these were constructed from one dimensional measurements, therefore were not instantaneous. In this paper we present two dimensional magnetic maps using high resolution filtergrams and we discuss the blue-red asymmetry and the limitations of the observations.

2.- OBSERVATIONS

High resolution (0.75 arc sec) filtergrams were obtained with the Tower telescope and the universal filter (UBF) of the Sacramento Peak Observatory. Each wing of 6103 Ca I was simultaneously observed in right and left circularly polarized light, consequently the atmospheric

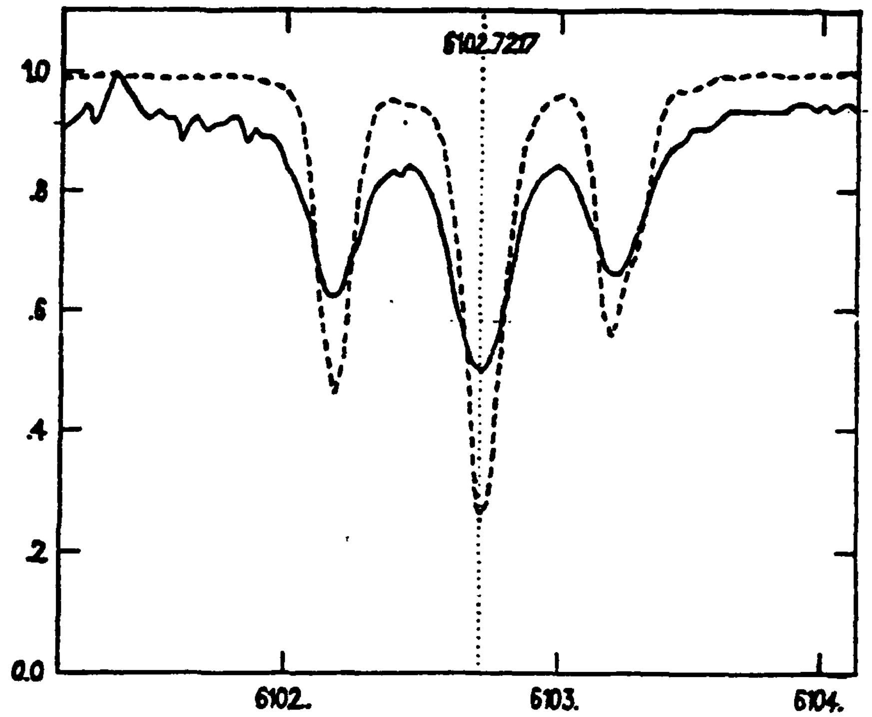

Figure 1: The dashed curve shows the line profile from the AFGL Atlas, while the solid curve is the scan of the line profile obtained with the UBF over an out of focus image of the sun at the center of the disk.

distortion was the same for both polarizations. A Wollastone prism was used for the separation of the two polarizations. The positions where we centered the filter in the blue and the red wing were those which gave the best signal to noise ratio for the magnetic field and were determined empirically; the shift from the line center was ±70 mÅ. The UBF was carefully checked before the run and the small line shift due to the solar rotation was taken into account.

The filter bandwidth at 6103 Å was 186 mÅ, while the scale of the image on the film was 10 arc sec/mm. The field of view was 100 by 200 arc sec and the telescope was pointed in a quiet region near the center of the disk, at N18 W12.

The vignetting effect was important, therefore flat-field pictures, with the solar image outfocused, were used for the correction. A step wedge was used for the photometric calibration.

We digitized the best frames at each wavelength with the fast microphotometer of Sac Peak and got an equivalent matrix of 700 by 780 pixels. The spot size was 0.7 arc sec and the sampling step 0.3 arc sec. We selected two regions for mapping of the magnetic field; one region was bipolar, while the other was unipolar with two separate components.

3.- DATA REDUCTION AND RESULTS

Magnetograms were obtained using the "weak field" approximation. Under this assumption, the subtraction of the two opposite polarity images in each wing gives a signal proportional

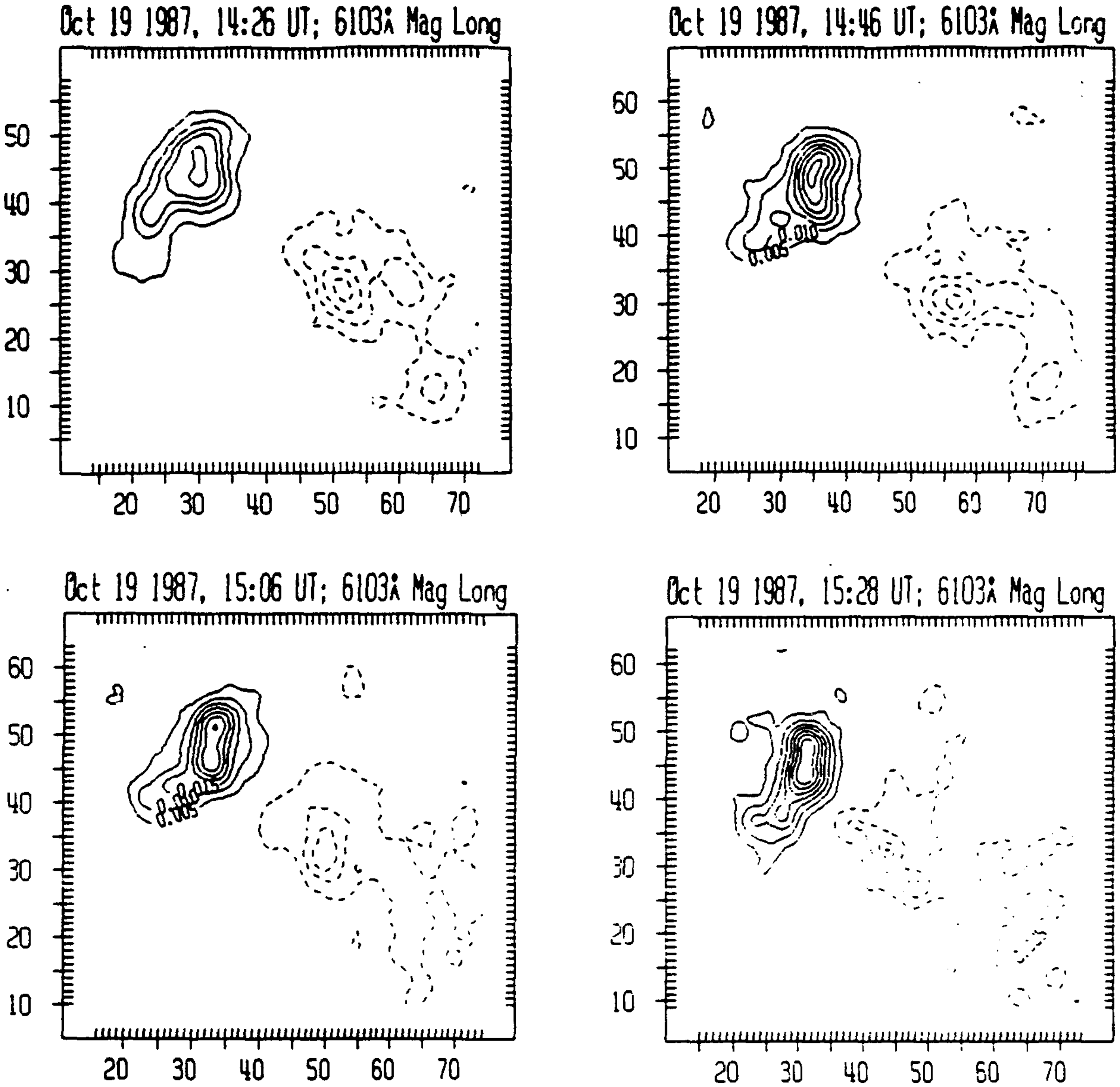

Figure 2: Magnetic field maps of the measured longitudinal component for a bipolar region. Each map is the result of averaging of 5 min of observations. Solid and dashed contours indicate positive and negative polarities; contours are in steps of 0.3% contrast (~30 Gauss). Tickmarks are every 0.3 arc sec.

the Zeeman shift and the derivative of the line profile; the reference profile was obtained with the UBF at the center of the disk, with the solar image outfocused (Figure 1).

For each wing the superposition of the two opposite circular polarization pictures was carried out on the computer screen, by moving one picture with respect to the other, until a uniform background away form the magnetic regions was obtained on the subtracted image. The final magnetic map is the average of the maps in the two wings, which were superposed using the same method.

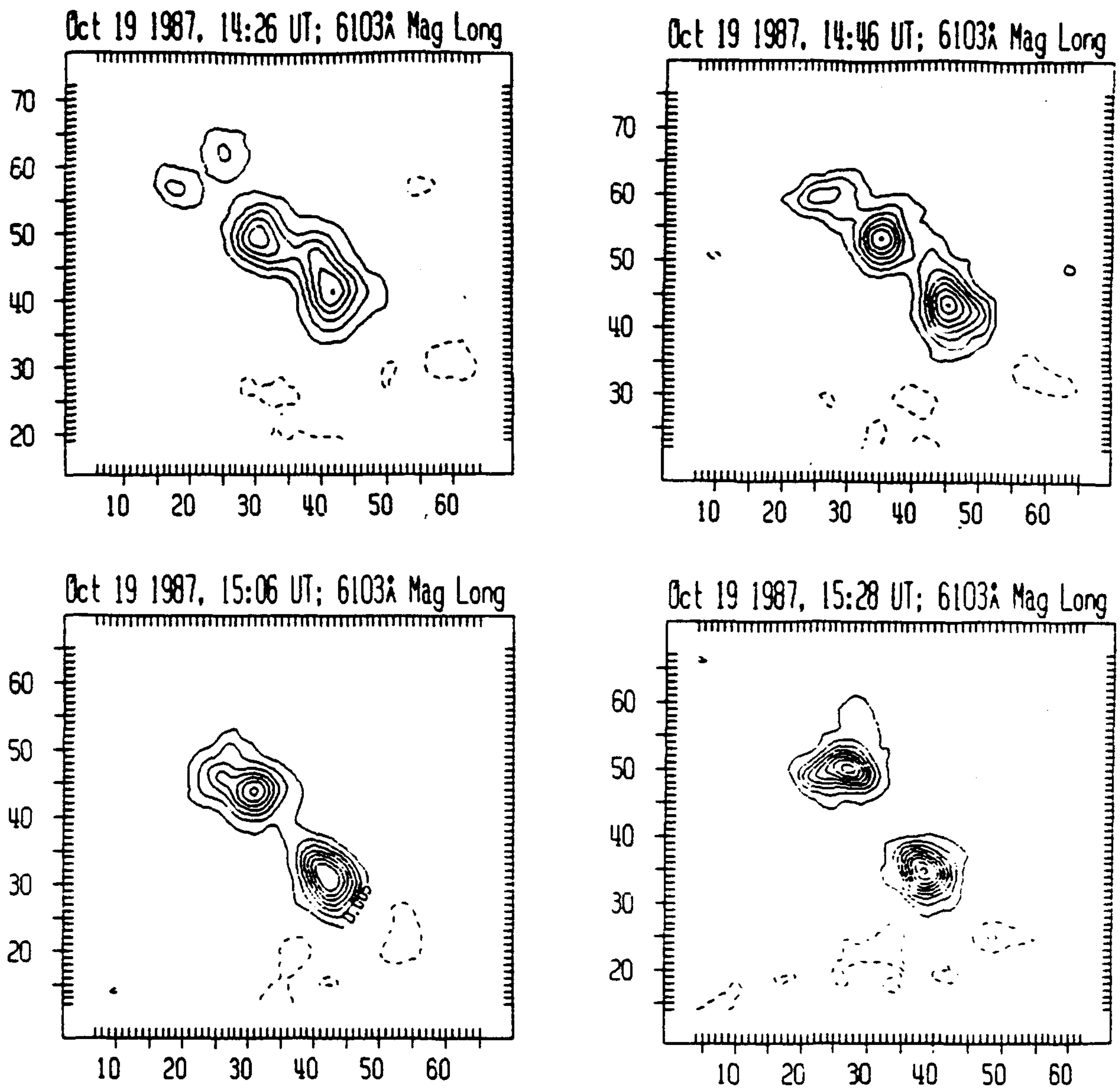

Figure 3: Magnetic field maps similar to those of figure 2, but for the unipolar region.

Figures 2 and 3 give the maps of both regions, averaged further over a five minute interval in order to reduce the effect of the five-minute oscillations and to improve the signal to noise ratio, at the expense of a slightly degraded spatial resolution. The total flux in both regions is of the order of 10^{19} Mx. The maximum magnetic field in both regions is 330 Gauss.

Choosing the best filtergrams of the sequence we compared the measurements of the longitudinal magnetic field in the red and in the blue wing (Figure 4). In both regions the measurements of the magnetic field were higher in the blue than in the red wing, which is a manifestation of the well-known blue-red asymmetry of the line profile. The slope of the red-blue regression line is 0.7, that is the values measured in the blue wing were 40% higher than those of the red.

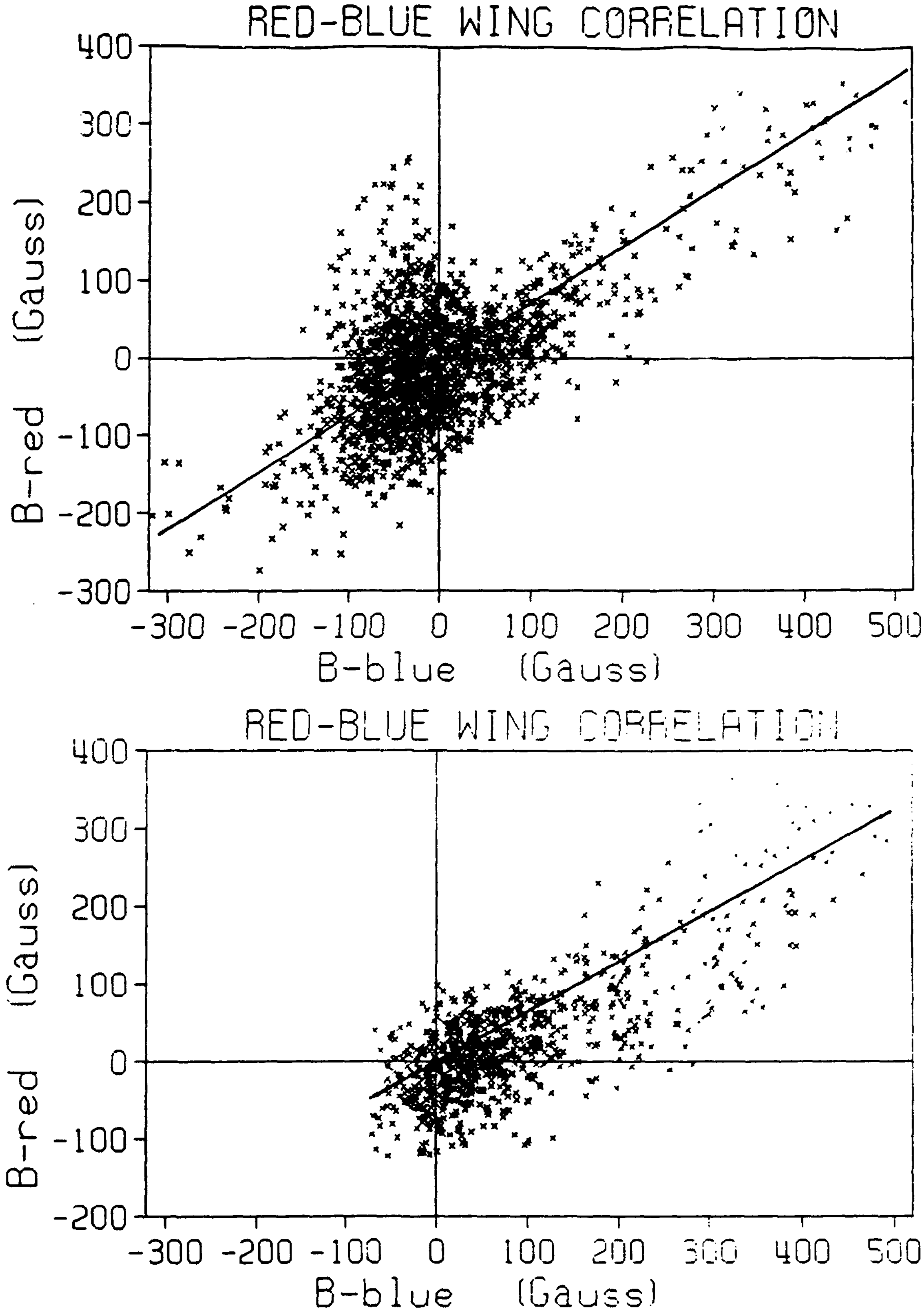

Figure 4: Correlation diagram between the values of the longitudinal magnetic field in the red wing and those in the blue wing, for the two regions: (a) bipolar and (b) unipolar.

4.- DISCUSSION

The values of the magnetic field intensity that we obtained using the "weak field" approximation are lower than the true peak intensity because we used a non-magnetic Stokes I profile as reference. The I profile in a magnetic region would be less deep and the slope in the wings would be smaller, leading to an underestimation of the magnetic field intensity. The observed values are reduced further due to loss of circular polarization by the telescope optics and the entrance window (the loss because of the window is about 20%). It is also possible that mixed polarities which cannot be resolved might be present inside the dominant polarity region, reducing even further the values of the intensity of this dominant polarity.

These two factors, together with the effect of spatial resolution which is still insufficient to show the elementary flux-tubes can reduce a kG field to the observed values. Moreover the presence of unresolved mixed polarity field may have an important effect on the red-blue asymmetry.

However, although the magnetic field is underestimated, these magnetograms have the advantage of a satisfactory spatial resolution; moreover, since a map can be obtained every 32 sec, changes of the magnetic features can be closely followed.

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